

NETWORK MODELS, METHODS, AND COMPUTER PROGRAM PRODUCTS  
FOR MANAGING A SERVICE INDEPENDENT OF THE UNDERLYING  
NETWORK TECHNOLOGY

RELATED APPLICATION

This application claims the benefit of U. S. Provisional Application No. 60/220,339, filed July 24, 2000, the disclosure of which is hereby incorporated herein by reference.

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BACKGROUND OF THE INVENTION

The present invention relates generally to the field of communication networks, and, more particularly, to managing a network service.

In recent years, regulatory forces worldwide have been working to cope with the need to modernize public networks to support the increasing number of data applications that the Internet embodies. Many users access the Internet through relatively low bandwidth public switched telephone network (PSTN) dial-up connections. Although this level of performance may satisfy many consumers, higher access speeds would almost certainly provide additional gratification.

Regulators in the United States and worldwide have recognized the value of creating a true "information society" and have taken steps to encourage, or even mandate, universal broadband access. Despite the demand for higher Internet access speeds from consumers, and the mandates of universal broadband access by regulatory agencies, it is unlikely that today's networks will evolve towards a universal Internet Protocol (IP) network.

The public voice network is generally considered the underpinning of modern communications. National policies in many industrialized countries reflect the need

to ensure the stability of voice services, which are typically based on time division multiplexing (TDM) technology. Because IP networks generally do not provide the same degree of reliability and stability as current voice networks based on TDM, it is unlikely that IP networks will replace TDM voice networks anytime soon.

5           Accordingly, it is unlikely that today's communication networks will evolve towards a single worldwide network based on a single structure, owned by a single administration, and obeying a single technical discipline. Instead, communication networks may comprise access networks that support voice services and other, more advanced, data services, and are based on technologies like asynchronous transfer  
10   mode (ATM). Communication networks may also comprise core networks that support IP, ATM, frame relay, TDM, and various optical technologies based on dense waveguide division multiplexing (DWDM).

          Network technologies, therefore, may diverge instead of converging. Consumers of network services, however, may demand a uniform interface  
15   irrespective of how diverse the underlying network technology may be. Service providers and network owners may be concerned with strategies for exploiting the potential of higher network access speeds without undermining the revenues and stability of current service offerings. Accordingly, there exists a need for improved systems and methods for managing a service that may allow both the service  
20   consumer and the service provider to benefit.

#### SUMMARY OF THE INVENTION

          Embodiments of the present invention provide network models, methods, systems, and computer program products for managing a service. For example, a  
25   network model for managing a service comprises an end service domain that associates the service with an end service provider. The end service domain comprises a plurality of wholesale service domains that each comprise one or more networks that provide traffic transport for the end service domain. One or more gateways are used to couple one of the wholesale service domains to another one of  
30   the wholesale service domains, and to perform protocol translation on traffic passing between the coupled wholesale service domains. In addition, one or more gateways are configured to couple a user to the end service domain, and are further configured to communicate with the user by a protocol associated with the service. A process

domain provides an abstract representation of applications provided by the end service domain. Advantageously, by modeling a service delivery environment as an end service domain that comprises network domains and process domains, the present invention may facilitate management of a service independent of the underlying network technology.

In further embodiments of the present invention, a service management system is communicatively coupled to the end service domain and comprises a plurality of software objects that represent resources in the end service domain and a policy database that comprises rules for associating requirements of the service with resources in the end service domain.

In particular embodiments of the present invention, the requirements of the service comprise service requirements associated with the user and business requirements associated with the end service provider.

Although embodiments of the present invention have been described primarily with respect to network model aspects of the invention, it will be understood that the present invention may also be embodied as methods, systems, and computer program products.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Other features of the present invention will be more readily understood from the following detailed description of specific embodiments thereof when read in conjunction with the accompanying drawings, in which:

**FIG. 1** is a block diagram that illustrates network model architectures in accordance with embodiments of the present invention;

**FIG. 2** is a block diagram that illustrates data processing systems in accordance with embodiments of the present invention;

**FIG. 3** is a software architecture block diagram that illustrates methods, systems, and computer program products for managing a service in accordance with embodiments of the present invention;

**FIG. 4** is a flowchart that illustrates exemplary operations for managing a service in accordance with embodiments of the present invention.

**FIG. 5** is a block diagram that illustrates virtual services in accordance with embodiments of the present invention; and

**FIG. 6** is a flowchart that illustrates exemplary operations for managing a service in accordance with further embodiments of the present invention.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

5 While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and will herein be described in detail. It should be understood, however, that there is no intent to limit the invention to the particular forms disclosed, but on the contrary, the invention is to cover all modifications, equivalents, and alternatives falling within  
10 the spirit and scope of the invention as defined by the claims. Like reference numbers signify like elements throughout the description of the figures.

The present invention may be embodied as methods, systems, and/or computer program products. Accordingly, the present invention may be embodied in hardware and/or in software (including firmware, resident software, micro-code, *etc.*).

15 Furthermore, the present invention may take the form of a computer program product on a computer-usable or computer-readable storage medium having computer-usable or computer-readable program code embodied in the medium for use by or in connection with an instruction execution system. In the context of this document, a computer-usable or computer-readable medium may be any medium that can contain,  
20 store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

The computer-usable or computer-readable medium may be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific  
25 examples (a nonexhaustive list) of the computer-readable medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, and a portable compact disc read-only memory (CD-ROM). Note that the computer-usable  
30 or computer-readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via, for instance, optical scanning of the paper or other medium, then compiled, interpreted, or

otherwise processed in a suitable manner, if necessary, and then stored in a computer memory.

In many traditional networks, services are tied to a particular technology framework. It is anticipated, however, that services may eventually transcend networks. That is, a wide range of services may be provided on a network that comprises a combination of devices embracing a variety of architectures and protocols. A user may require services delivered in a protocol that is not supported by one or more sub-networks or core networks within the larger network domain. The present invention may provide network models, methods, systems, and computer program products for managing a service that are independent of the underlying network technology. Thus, the present invention may provide improved flexibility in service management that may allow services to be customized for consumers such that consumers may view a network as a personal service network.

Referring now to **FIG. 1**, a network model architecture, in accordance with embodiments of the present invention, comprises an end service domain (ESD) **22** that is communicatively coupled to a service management system **24**. A service delivery environment may comprise one or more ESDs **22** that are each associated with an end service provider (ESP). An ESP represents a provider of a service to consumers, which may be, for example, end users and/or other service providers. Conventional services, such as Internet service, may be modeled as an ESD and retail carriers, such as local exchange carriers (LECs), inter-exchange carriers (IXCs), and Internet service providers (ISPs) may be represented as ESPs.

As shown in **FIG. 1**, ESD **22** comprises a plurality of core wholesale service domains (WSDs) **26a**, **26b** and access WSDs **28a**, **28b**, **28c**, and **28d**. Each WSD comprises one or more networks that provide the access and transport connections that are used by the ESD **22** and associated ESP. Moreover, each WSD may have a wholesale service provider (WSP) associated therewith. Each WSD may be viewed as an "interior ESD" in the sense that retail services to one provider may be wholesale services to another provider. Access WSDs **28a**, **28b**, **28c**, **28d** correspond to those WSDs that couple customers/users to the ESD **22** (*i.e.*, those WSDs through which customers/users access the ESD **22**). By contrast, core WSDs **26a**, **26b** correspond to those WSDs that are not used to couple customers/users to the ESD **22**. Examples of WSDs include facility networks that are owned and/or operated by LECs and/or IXCs,

as these networks may provide transport and access resources to logical service networks that overlay them.

WSDs (core and access) are connected to each other and to customers/users through devices called gateways (GWs). As shown in **FIG. 1**, the ESD **22** comprises eight gateways **32a**, **32b**, **32c**, **32d**, **32e**, **32f**, **32g**, and **32h** that are connected to various ones of the WSDs. More specifically, GWs **32a**, **32d**, **32g**, and **32h** connect customers/users to access WSDs **28a**, **28b**, **28c**, and **28d**, respectively, and are configured to communicate with the customers/users using a protocol associated with an ESD service. On the other hand, GWs **32b**, **32c**, **32e**, and **32f** connect WSDs to each other inside the ESD **22**. GW devices may be embodied as translation devices that are configured to translate between protocols used by different ESDs and/or WSDs. Examples of conventional GW devices include, but are not limited to, those network devices that are used to link leased lines to IP networks, or ATM networks to PSTN networks. GW devices, in accordance with embodiments of the present invention, may be called "service switches" and/or "service points of presence (POPs)." These service-switch GW devices, when operated at the edge of the ESD **22**, such as GWs **32a**, **32d**, **32g**, and **32h**, may be configured to analyze incoming traffic and to segregate the incoming user traffic according to application. When operated internal to the ESD **22**, such as GWs **32b**, **32c**, **32e**, and **32f**, the service-switch GW devices may be configured to bridge dissimilar network protocols.

The ESD **22** further comprises a process domain **34** that provides an abstract representation of applications provided by the ESD **22**. More specifically, the process domain **34** represents those network processes that a customer/user of the ESD **22** would recognize as an application provided by the network. For example, many TCP/IP networks include a service called the Domain Name System (DNS) that provides logical name-to-address translation. Network DNS servers that provide this service may be viewed as network processes. Network process resources may be located anywhere in the ESD **22**, including interior to the WSDs. In accordance with embodiments of the present invention, these network processes are represented as the process domain **34**.

The service management system **24** may communicate with the ESD **22** to collect, for example, performance, configuration, topology, timing, and/or traffic data therefrom. The data collected by the service management system **24** are stored in

repositories for use by other applications. The repositories may be implemented as relational database management systems (RDBMS) that support the structured query language (SQL). It may be desirable to store the collected data in a SQL database to facilitate access of the collected data by other applications. Advantageously, applications may access a SQL database without having to know the proprietary interface of the underlying RDBMS.

Client applications **42** may communicate with the service management system **24** to access reports generated by the service management system **24** based on analyses of the collected data and to manage the services provided by the ESD **22** (e.g., determine whether a service provided by the ESD **22** is in conformance with an agreed upon quality of service). Capacity planning applications **44** may communicate with the service management system **24** to assist an administrator in shaping/configuring the topology/shape of the ESD **22** and/or to distribute traffic carried by the ESD **22**. Billing applications **46** may communicate with the service management system **24** to generate bills based on analyses of the data collected from the ESD **22**. Finally, service provisioning applications **48** may communicate with the service management system **24** to facilitate the introduction of new services into the ESD **22** or another ESD.

The service management system **24** and/or data processing system(s) supporting the client applications **42**, the capacity planning applications **44**, the billing applications **46**, and the service provisioning applications **48** may be configured with computational, storage, and control program resources for managing a service, in accordance with embodiments of the present invention. Thus, the service management system **24** and the data processing system(s) supporting the client applications **42**, the capacity planning applications **44**, the billing applications **46**, and the service provisioning applications **48** may each be implemented as a single processor system, a multi-processor system, or even a network of stand-alone computer systems.

Although **FIG. 1** illustrates an exemplary network model architecture architecture, it will be understood that the present invention is not limited to such a configuration but is intended to encompass any configuration capable of carrying out the operations described herein.

Referring now to **FIG. 2**, an exemplary data processing system **50** architecture is illustrated, which may be used in embodiments of the service management system **24** and the data processing system(s) supporting the client applications **42**, the capacity planning applications **44**, the billing applications **46**, and the service provisioning applications **48**, in accordance with the present invention. The data processing system **50** may include input device(s) **52**, such as a keyboard or keypad, a display **54**, and a memory **56** that communicate with a processor **58**. The data processing system **50** may further include a storage system **62**, a speaker **64**, and an input/output (I/O) data port(s) **66** that also communicate with the processor **58**. The storage system **62** may include removable and/or fixed media, such as floppy disks, ZIP drives, hard disks, or the like, as well as virtual storage, such as a RAMDISK. The I/O data port(s) **66** may be used to transfer information between the data processing system **50** and another computer system or a network (*e.g.*, the Internet). These components may be conventional components such as those used in many conventional computing devices and/or systems, which may be configured to operate as described herein.

**FIG. 3** illustrates a processor **72** and a memory **74** that may be used in embodiments of the service management system **24** in accordance with the present invention. The processor **72** communicates with the memory **74** via an address/data bus **76**. The processor **72** may be, for example, a commercially available or custom microprocessor. The memory **74** is representative of the overall hierarchy of memory devices containing the software and data used to manage a service in accordance with embodiments of the present invention. The memory **74** may include, but is not limited to, the following types of devices: cache, ROM, PROM, EPROM, EEPROM, flash, SRAM, and DRAM.

As shown in **FIG. 3**, the memory **74** may contain up to five or more major categories of software and/or data: the operating system **78**, the Common Object Request Broker Architecture (CORBA) program module **82**, the mediation facilities module **86**, the object manager program module **88**, and the data module **92**.

The operating system **78** controls the operation of the computer system. In particular, the operating system **78** may manage the computer system's resources and may coordinate execution of programs by the processor **72**. The CORBA module **82**



may be configured to allow the software modules in the memory 74 to be implemented as an object-oriented system and may facilitate communication between the various software objects. In addition, the CORBA module 82 may also allow the objects to be distributed across a heterogeneous network. For example, the objects  
5 may be distributed across different data processing systems in a network and yet appear to each other as if they were local. In a distributed object-oriented computer system, client objects may be given object handles to reference remote server objects. A remote object is an object whose class is implemented in a process that is different from the process in which the object handle resides. Moreover, a remote object may  
10 be implemented on a data processing system that is remote from the data processing system on which the object handle resides. An object handle identifies a remote, server object and may allow a client object to invoke member functions of the remote object. CORBA is an exemplary distributed object module that may be used in embodiments of the present invention. It should nevertheless be understood, however,  
15 that other distributed object models, such as the Distributed Component Object Model (DCOM) and the Java Remote Method Invocation (RMI) model may be used in other embodiments of the present invention. The CORBA model is discussed briefly hereafter.

The CORBA model is based on an Object Request Broker (ORB) that acts as  
20 an object bus over which objects may transparently interact with one another irrespective of whether they are located locally or remotely. A CORBA server object supports an interface that consists of a set of methods. A particular instance of a CORBA server object is identified by an object reference. The object reference may be used by a CORBA client object to make method calls to the CORBA server object  
25 as if the CORBA client object and the CORBA server object shared the same address space. Resources for developing distributed software using CORBA may be obtained from third party software providers.

Returning to **FIG. 3**, the mediation facilities module 86 may be configured as a set of software objects that are used to represent each resource in the ESD by  
30 identifying the resource's name, capabilities, limitations, and any additional relevant characteristics of the resource. Thus, in accordance with embodiments of the present invention, a device, a service model, a customer, a third-party software package, *etc.*, in the ESD 22 may all be represented by respective mediation facilities module 86

software objects. All resources of a given type appear identical to the service management system **24** software once these resources are represented by mediation facilities module **86** objects. In accordance with object oriented design and programming principles, any function or method that can be performed by or on a given resource type can be performed by or on any resource of that type.

Advantageously, the mediation facilities module **86** may allow the present invention to manage a service independent of the underlying network technology, as the various network devices are modeled by particular mediation facilities module **86** objects that are associated therewith.

The object manager module **88** may be configured to generate a new mediation facilities module **86** object when a new service is needed and/or when a new device is installed in the ESD **22**. The object manager module **88** may be further configured to create associations between mediation facilities module **86** objects. For example, when device interfaces are created in the ESD **22**, their linkage to service models, process and connection routing, billing, service support systems (SSS), and other operational support system (OSS) functions may be provided by representing the device interface by a mediation facilities module **86** software object. Similarly, the service management system **24** may utilize third-party software by representing the third-party software by a mediation facilities module **86** software object. For example, a third-party billing system or trouble-ticket system may be linked to all of the device objects from which it receives billing data or problem reports through the CORBA module **82**.

The data module **92** may comprise a policy rules database **94** and a resource capabilities database **96**. The policy rules database **94** comprises a set of rules for associating service requirements with resources in the ESD **22**. The service requirements may comprise requirements associated with a customer/user and/or business requirements associated with a service provider. The resource capabilities database **96** comprises information regarding the capabilities of resources in the ESD **22**. In other embodiments of the present invention, the capabilities of resources in the ESD **22** need not be stored in the resource capabilities database **96**, but instead may be communicated from the ESD **22** resources to the service management system **24** via, for example, capability reports.

Although **FIG. 3** illustrates an exemplary software architecture that may be used for managing a service in accordance with embodiments of the present invention, it will be understood that the present invention is not limited to such a configuration, but is intended to encompass any configuration capable of carrying out the operations described herein.

Computer program code for carrying out operations of the present invention may be written in an object-oriented programming language, such as Java, Smalltalk, or C++. Computer program code for carrying out operations of the present invention may also, however, be written in conventional procedural programming languages, such as the C programming language or compiled Basic (CBASIC). Furthermore, some modules or routines may be written in assembly language or even micro-code to enhance performance and/or memory usage.

The present invention is described hereinafter with reference to flowchart and/or block diagram illustrations of methods, systems, and computer program products in accordance with exemplary embodiments of the invention. It will be understood that each block of the flowchart and/or block diagram illustrations, and combinations of blocks in the flowchart and/or block diagram illustrations, may be implemented by computer program instructions and/or hardware operations. These computer program instructions may be provided to a processor of a general purpose computer, a special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer usable or computer-readable memory that may direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer usable or computer-readable memory produce an article of manufacture including instructions that implement the function specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a

computer implemented process such that the instructions that execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart and/or block diagram block or blocks.

With reference to the block diagram of **FIG. 5** and the flowcharts of **FIGS. 4** and **6**, exemplary operations for managing a service, in accordance with embodiments of the present invention, will be described hereafter.

Referring now to **FIG. 4**, exemplary operations for managing a service begin at block **102** where a service model is generated that comprises separate virtual processes and virtual services. This is illustrated, for example, in **FIG. 5** where a virtual service model **104** is populated with user parameters and policies, such as those policies contained in the policy rules database **94** and/or the resource capabilities database **96** discussed hereinabove, as represented by the policy computed service topology map **106** to separate the service model into its constituent virtual connections **108** and virtual processes **112**. The virtual connections are information routes through the ESD **22**, and the virtual processes are network-resident services, which are represented by the process domain **34** in the ESD **22**. Returning to **FIG. 4**, at block **114**, each of these virtual elements, *i.e.*, virtual connections **108** and virtual processes **112**, are assigned to one or more of the "real" resources comprising the ESD **22**.

Referring now to **FIG. 6**, exemplary operations for managing a service, in accordance with further embodiments of the present invention, begin at block **116** where service points are identified in the ESD **22**. Service points correspond to locations/resources in the ESD **22** through which a user accesses the service and/or that host a network process/network-resident application represented by the process domain **34**. The service management system **24** may then reserve server resources in the ESD **22** at locations identified as host sites for network-resident applications at block **118**. Next, at block **122**, a virtual connection topology is created at the meta-route level.

As shown in **FIG. 5**, a GW-to-GW meta-route map **124** may be constructed based on the virtual connections **108** by specifying an ordered list of GWs that defines a route through the ESD **22** for each virtual connection. In addition to the meta-route map **124**, a WSD interior route map **126** may also be generated that provides the

specific paths between pairs of GWs through single WSDs. In accordance with embodiments of the present invention, the service management system **24** need not generate the WSD interior route maps **126** as GW devices may generate these routes through the individual WSD interiors using protocols associated with the respective WSDs. Thus, the service management system **24** may generate a virtual connection by specifying the hops between GW devices and delegating the responsibility for creating the connections within the respective WSDs to the pairs of GW devices respectively connected by the WSDs.

The flowcharts of **FIGS. 4** and **6**, and the block diagram of **FIG. 5** illustrate the architecture, functionality, and operations of embodiments of the service management system **24** software. In this regard, each block represents a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that in some alternative implementations, the function(s) noted in the blocks may occur out of the order noted in **FIGS. 4 - 6**. For example, two blocks shown in succession may, in fact, be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending on the functionality involved.

Many variations and modifications can be made to the preferred embodiments without substantially departing from the principles of the present invention. All such variations and modifications are intended to be included herein within the scope of the present invention, as set forth in the following claims.